PERFORMANCE OF VARIOUS BREEDS OF SWINE UNDER CENTRAL TESTING STATION CONDITIONS IN WINTER AND SUMMER

by

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INTRODUCTION

Improvement of hogs through breeding depends primarily upon selection. Accuracy of selection, therefore, is very important. During the past 60 years, in order to increase accuracy of selection, several testing methods have been devised by hog breeders in their attempt to measure the various traits of economic importance. Progeny testing was initiated in Denmark before 1900 and sometime thereafter it was used in the other countries in Europe, in Canada, in New Zealand, and in the United States. It has generally been used to test the performance of the litter. In the late 1930's, swine breed associations began promoting production registry of litters, and established standards for the certification of litters. However, a more effective testing procedure has been established in recent years. Swine testing or swine improvement associations have been organized and are operating in many states. In 1956 Iowa State University began testing boars. Since then, testing stations have been set up in 25 states. On-farm litter testing has been started in several states and is used to increase the effectiveness of selection in purebred herds.

The Kansas State swine evaluation program was established in 1958 and since then, six groups of swine including 316 boars and 157 barrows have been fed at the Kansas swine testing station. The purpose of this study was to analyze the data collected on the six groups of test animals. Information studied included daily

gains, feed efficiency, backfat thickness and carcass characteristics of the various breeds in different seasons.

LITERATURE REVIEW

In the past, several papers have dealt with the measurement of live-hog backfat thickness, evaluation of carcass quality, and environmental influence on the growth rate and feed efficiency. However, little has been said about breed differences. This literature review attempts to summarize the work concerned with the above mentioned factors. In addition, papers discussing the heritability of the economically important traits and the reported differences in various stages of growth have also been reviewed. Due to the decline in the price of lard as compared with the price of lean cuts of pork, researchers have paid considerable attention to the evaluation of the carcass and the relationship of carcass quality to live hog measurement. Many measurement methods have been studied in recent years as possible methods for estimating carcass quality.

Prediction of Carcass Quality by Various Live-hog Measurement Methods

As early as 1939, Phillips, Hetzer and Hiner tried to use scores for various characteristics to predict the yields of several different cuts of the hog carcass, they found that there was a highly significant correlation between some of the scores and carcass quality. (However, none of the correlations were

large enough to be very important from the practical standpoint). Hetzer et al. (1950) used certain body measurement which included length from ear to tail, height at the shoulders, width at the shoulders, width of middle, width at ham, depth at the chest, depth of middle and circumference at the chest to predict the combined yield of ham, loin, bacon, picnic shoulder, shoulder butt and the yield of lean meat in the hams. From their study it was concluded that for both barrows and gilts, the depth of middle was the most important item in determining the yield of the five cuts. Next in importance were width of middle and height at the shoulders for the barrows and height at the shoulders and width at the shoulders for the gilts.

Hazel and Kline (1952) developed a method of measuring the backfat thickness on the live hog. It was found in their study that the average of the live hog measurements was a more accurate indicator of leaness and carcass value than was the average of the carcass backfat measurements.

Kraybill et al. (1951) used the solubility of antipyrine in body water as a means for measuring the carcass value.

Lamprecht et al. (1957) successfully applied ultra-high frequency sound reflection techniques to live swine and pork carcasses as a means of measuring fat thickness. Later Hazel and Kline (1959) reported significant relationships between ultrasonic measurements of fat and the cutting percentage of hogs. The correlations between average ultrasonic probe at a frequency of 25 mc/s and percent lean cuts was -.90. The corresponding

correlations with probes at a frequency of 1.5 mc/s was -.76 while that with the mechanical probe (metal ruler) was -.89. In particular, the ultrasonic probe at the loin (2.5 mc/s) gave a high correlation with percent ham.

Recently the lean meter has been used in place of the metal ruler in measuring backfat on the live animal. However, Pearson et al. (1957) indicated that there was little difference in the estimates of backfat thickness and percent of either lean or primal cuts when the lean meter and the metal ruler were compared.

The relationship between carcass quality and various carcass measurements has also been studied. Hiner (1937) proposed to measure the loin area at the last rib. Kline and Hazel (1944) indicated that there was no difference among the correlations between percent lean cuts and loin area at the tenth and at the last ribs, although the latter area was slightly more closely related to percent loin. The correlation coefficients between the percent lean cuts and the area at the tenth rib was .66. A coefficient of .65 was reported when area at the last rib was used.

Pearson et al. (1958) reported that the relationships of carcass length, backfat thickness and live probe to carcass cut out values were as follows:

Trait	Carcass length	Backfat thickness	Live probe
Lean cuts - live	.42	-.38	-.55
Lean cuts - carcass	.33	-.47	-.61
Primal cuts - live	.35	-.25	-.38
Primal cuts - carcass	.36	-.39	-.38
Fat trim	-.32	.52	.64

Pearson also reported that percentage loin and carcass length are positively correlated. However, Holland and Hazel (1958) reported that the carcass length was the least accurate of the carcass measurements in predicting yield of the cuts.

Among those methods mentioned above for measuring carcass quality in the live hogs, visual estimates and live body measurements such as height and width are not sufficiently accurate to warrant their general use. Chemical methods, as illustrated by the solubility of antipyrine in body water (Kraybill et al., 1951) may have greater accuracy than the backfat probing technique. However, the latter has considerably greater usefulness in being more rapid and easier to apply as well as in the fact that the results are immediately available. Direct carcass measurements which require slaughter cannot be used for the evaluation of breeding animals. The ultrasonic method may not be too useful for measuring fatness in swine except in the case of young pigs which have relatively small amounts of fat. Price et al. (1960) reported that the correlation coefficients between the lean cuts on a carcass basis and fat ultrasonic reflection readings, live probe and carcass fat probe were -.70, -.80 and -.74 respectively. Price et al., (1960) measured the cross-sectional area of the loin

eye muscle in live swine by ultrasonic reflections. The correlation between live estimated area and actual eye muscle area was 0.74. However, it would have been desirable to obtain duplicate or triplicate sets of readings on each animal, thus getting a repeatability estimate. The time involved and the fatigue of both the operator and animal made this impractical. It would appear that the mechanical probe is the most simple, accurate and dependable method for estimating carcass leaness.

Hazel et al. (1952) measured backfat at four places, immediately behind the shoulder, middle of the back, middle of the loin, and middle of the loin over the exact middle of the body. They reported that the most accurate locations were just behind the shoulder and at the middle of loin about 1 1/2 inches off the mid-line of the body. However Holland et al. (1958) reported that the probe behind the shoulder was the poorest location for measuring backfat on the live hog. Zobriskey et al. (1954) reported that correlations between the probe behind the shoulder and percent lean cuts and percent fat cuts were lower than the correlations involving probe at the hip and the probe at the top of the ham. Holland et al. (1958) measured the backfat at three locations; behind shoulder, middle back, middle of the loin and found the average of the three backfat probes was the most accurate indicator of percent lean cuts and percent fat cuts among the live animal measurements.

Robison et al. (1960) indicated that the 154 day weight and backfat at the loin were the two measurements of highest value in

predicting percent lean cuts. The addition of width behind the shoulders length of foreleg, backfat at the shoulder or circumference of foreleg added little to the accuracy of the equation containing weight and backfat at the loin. However, the width behind the shoulders showed some promise of being useful for increasing the precision of predicting carcass merit.

De Pape et al. (1956) reported the correlations between backfat probe measurements and carcass traits as follows:

Traits	Carcass backfat	Average of six probes	Average of two probes
Carcass backfat	--	.69	.36
Percent lean cuts	-.66	-.57	-.07
Percent primal cuts	-.58	-.67	-.13
Loin lean area	-.28	-.26	--
Carcass length	-.11	-.33	-.05

However, correlation between backfat probe measurements and the carcass traits varied in different years and different locations. These differences could be due to breed, worker, probe site, probe depth, or other unknown factors. Following are the correlations between the backfat thickness measured at different places and the percent lean cuts as reported by Iowa and Missouri Agricultural Experiment Station workers.

Probe site	Iowa 1953	Iowa 1958	Iowa 1959	Missouri 1958
Behind shoulder (shoulder probe)	-.69	-.60	-.806	-.36
Mid-back (hip probe)	-.48	-.72	-.824	-.35
Mid-loin (ham probe)	-.65	-.71	-.752	-.43
Av. of probes	-.75	-.78	-.790	

Sex, Season, Ambiant Temperature and Dietary Effect on Swine Performance

A number of recent carcass quality studies have dealt with the effects of sex, season, varying levels of protein, crude fiber, and antibiotic supplements.

Theoretically, a higher dietary protein level or a higher quality protein should result in greater muscle development and less fat deposition. This was verified in several experiments. Speer et al. (1957) reported that live probe backfat measurements which were made on each boar at two points (shoulder and loin) decreased significantly, as the protein level increased. This linear response was observed previously by Ashton et al. with barrows and gilts. Noland et al. (1960) reported that the carcasses of pigs fed either 16 percent or 20 percent protein were longer ($P < .01$) and had a greater yield of primal cuts than those from the 12 percent protein group.

Audman et al. (1960) reported that under pasture conditions, the pigs fed a 12 percent protein ration on pasture produced the thickest backfat and the highest average estimated percentage of

lean cut but differences were not significant. The pigs fed on pasture had a lower dressing percentage than those fed in dry lot.

Ashton (1946) and Ashton et al. (1955) reported no significant differences in carcass quality of pigs consuming rations that varied only 2 percent in protein content. Aunan et al. (1961) failed to obtain significant differences in carcass composition also due to the dietary protein level. This might be due to the advent of antibiotics and vitamin B_{12}. Growing pigs receiving these additives will apparently gain weight rapidly and efficiently, when fed rations containing less protein than previously recommended. It appears that the effects of dietary protein on carcass quality are relatively minor unless grossly inadequate protein levels are fed.

Limited feeding and the feeding of high fiber rations will also affect carcass quality. Merkel et al. (1958) found that the percent crude fiber was highly significantly correlated (-.960 and -.904 respectively) with dressing percentages and backfat thickness. Hochstetler (1959) reported that there was a significant decrease in rate of gain, feed efficiency, dressing percentage and percent of fat trim in pigs fed a ration containing 40 percent wheat bran. This was accompanied by a similar increase in lean and primal cuts on the carcass basis. Feeding various alfalfa levels in the ration will affect the backfat thickness and other carcass quality factors. Stevenson et al. (1960) reported that carcass length increased by significant amounts at

the 16 percent alfalfa level and further differences characteristic of a leaner carcass were observed when the highest alfalfa level (28 percent) was fed. Dressing percent, backfat and bacon thickness and total fat percent were all significantly decreased. The difference was not significant when the crude fiber content of the ration was less than 10 percent. TDN level was significantly correlated with backfat thickness (.741 Merkel et al. (1958). By restricting the energy intake of pigs lean pork carcass can be produced. Winters et al. (1949) reported the production of lean pork carcasses by restricting the energy intake of swine with limited hand feeding. Similar results have been obtained by replacing part of a high energy ration with fibrous feed (Crapton et al. 1959, Bohman et al., 1955, Merkel et al., 1958).

However, Merkel et al. (1958) pointed out that the level of crude fiber in the ration was more highly correlated with carcass quality than either TDN or protein level.

Antibiotics also affect carcass quality. However, Stevenson et al. (1960) reported that this effect was limited to the first period in their experiment (up to 125 pounds) in which it increased feed consumption and decreased backfat thickness.

Sex influences backfat thickness. Hetzer et al. (1956) reported that on the live animal, barrows exceeded boars significantly in backfat at 175, 200 and 225 pounds. Backfat thickness was less in barrows than in gilts at 150 and 175 pounds but

barrows exceeded gilts at 200 and particularly at 225 pounds. Thickness of backfat in gilts was significantly greater at each of the four weights than in boars. For each 10 pound increase in body weight, thickness of backfat would be expected to increase an average of .044, .057 and 0.042 inches in boars, barrows and gilts respectively. There was practically no difference in the slopes of the regressions for boars and gilts, but barrows significantly exceeded boars and gilts in rate of fat deposition. The increase in backfat thickness between 150 and 225 pounds averaged 0.32 inches in boars, 0.43 inches in barrows and 0.31 inches in gilts.

A similar study by Stevenson et al. (1960) also indicated a significant difference in backfat thickness between sexes. They reported that gilts had less thickness of bacon and of backfat and less total carcass fat than barrow littermates, but exceeded the barrows in carcass length and in the yield of five preferred cuts. This sex difference was significant at the one percent level.

Backfat thickness increases with age. De Pape et al. (1956) reported that probing at 56 and 84 days had little value in predicting the carcass backfat at slaughter weight. De Pape also pointed out that fat is the slowest of the major body tissues to develop and at stages of growth up to about 112 days the potential has not been expressed. Hetzer et al. (1956) reported that the correlations between live hog backfat measurements taken at various ages were .38, .58, .55, and .72 at 150, 175, 200, and 225 pounds live weight respectively.

The mechanical probe measurement of backfat thickness on pigs developed by Hazel and Kline in 1952 has been extensively utilized for selecting swine replacement stock for meatiness. This measurement far exceeds other live animal measurements and condition scores as an indicator of lean and fat in the carcass. Both genetically and phenotypically, the relationship of backfat thickness with percent of lean cuts is quite high although this measurement is indirect. Probe measurements appear to be sufficiently accurate and to have numerous other advantages over alternative method so they should be used widely in selecting for improvement in meatiness. However there are several environmental conditions which may affect live animal performance and carcass quality.

Seasonal Effects. Several reports have indicated that there are significant differences between seasons in feed efficiency, puberty age and carcass quality of swine. Zobrisky et al. (1959) found that in general carcasses from the hogs slaughtered in the spring were valued higher. However, the preferred cuts from the hogs slaughtered in the autumn scored higher than the preferred cuts from the spring slaughtered hogs. A large proportion of the spring slaughtered hogs had high yielding meaty cuts, but the cuts were lower in quality. They lacked firmness, marbling and desirable greyish pink color. The quality and meatiness scores were higher from hogs slaughtered in the autumn. The loin equivalents were higher for the hogs slaughtered in the spring as each individual cut yielded a greater percentage of the live hog.

The comparative data between autumn and spring slaughtered hogs were shown to be as follows:

Item	Autumn (1952)	Spring (1955)
Live weight, lb.	204.3	209.1
Dressing %	73.5	76.7
Empty digestive tract lb.	14.1	10.8
Preferred cuts %	43.5	49.0
Total fat %	19.4	17.4
Adjusted loin equivalent %	47.7	51.6
Average quality and meatiness scores:		
Ham	6.8	5.6
Loin	7.3	5.7
Shoulder	6.3	5.4
Belly	7.3	5.0

Zobrisky attributed the higher dressing percent of the spring slaughtered hogs principally to the lighter digestive tract, 10.8 vs 14.1 pounds and greater yield of preferred cuts 49.0 vs 43.5 percent.

The feed effect also varies in the two different feeding seasons. Noland et al. (1960) reported that during the summer time, increasing levels of energy resulted in faster gains at all levels of protein (12%, 16% and 20%). The pigs fed a 16 percent protein, 1200 calorie ration, gained 16.7 percent faster than those fed a 12 percent protein, 1050 calorie ration. However, during the winter time, this difference was only 3.7 percent. In a winter trial, in the period from weaning to 75 pounds, gains of pigs fed the 12 percent protein rations were depressed with increasing quantities of productive energy. However, at the 20 percent protein level, increasing levels of energy resulted in faster gains.

Stevenson et al. (1960) reported that pigs fed during the winter time ate more per day, gained weight faster and required more feed per pound of gain and had thicker bacon and backfat than summer fed pigs, and the percentage of the five preferred cuts was greater for the winter-fed pigs by a highly significant amount ($P < 0.01$) (This result agrees with Zobrisky). Summer-fed pigs had a longer carcass length also ($P < .01$).

Aunan et al. (1961) studied the influence of level of dietary protein on live weight gains and carcass characteristics. They found that there were highly significant differences in rate of gain between experiments. This difference was attributed to the differences in genetic background and to seasonal effects.

Season also affects the age of puberty but effects vary from breed to breed. Zimmerman et al. (1960) reported that the spring-born gilts attained puberty earlier than fall-born gilts in the Chester White breed. In the Poland China breed the fall-born gilts attained puberty earlier.

The differences in performance of pigs farrowed in different periods in one season is small. Bradford et al. (1953) failed to find significant differences of litter size, variability and weight for age between the pigs farrowed in the early, middle and late spring groups. However, a significant difference was found between years.

Ambiant Temperature Effects. All of the oxidations which take place in the body produce heat. Normally physiological regulation in the body keeps the body temperature constant under

varying external conditions. When the temperature of the air is too cold, the production of heat in the body is speeded up. This is done by increasing the oxidations in the muscle and other tissues. The critical temperature for swine ranges from 52°F to 68°F (Ritzman). Above this critical air temperature, the rate of metabolism remains rather constant with a rise in air temperature until the air becomes so hot that the body temperature increases. This will eventually cause greater heat production through a speed up of metabolism. In very hot weather the body temperature may rise since, especially in swine, it is very sensitive to the environmental temperature. The normal body temperature of swine ranges from 101.6 to 103.6°F. The rectal temperature begins to rise above normal at an environmental temperature of 85° to 90°F. If the relative humidity is 65 percent or above, the pig cannot tolerate prolonged exposure (7 hours) to an environmental temperature of 95°F. At an environmental temperature of 105°F. the pig is unable to stand an atmosphere of any humidity. A rectal temperature of 107°F. is near the danger point for swine. Robinson and Lee (1941) and Heitman and Hughes (1949) showed that as ambient temperature increased respiration increased.

In California Heitman (1951) reported that pigs weighing 50 to 125 pounds made the most rapid and efficient gains at an air temperature of about 73°F. while a temperature of about 61°F. was optimum for heavier hogs. In Kansas, Shelton (1883) reported that during a winter in which the temperatures at 8 a.m. ranged from 31° to -12°F. large hogs in warm quarters required 25 percent

less feed than those kept without shelter. Heitman et al. (1949, 1958) reported significant positive correlations between average daily gain and body weight at 50° and 60°F. and negative correlations at 80° to 110°F.

The degree of environmental temperature influence on the body temperature and respiration varies from breed to breed. Tidwell et al. (1951) reported that the average rise in body temperature of the Poland China pig for both 15 or 30 minutes exposure was significantly higher than for the Duroc pigs. Deighton (1929) indicated that at 61°F. Berkshire pigs could be maintained with less feed than could medium or large white pigs. Tidwell et al. (1951) reported that there was no significant difference between the sexes in respiration rate rise under 15 or 30 minutes exposure.

The use of a swine wallow or mist-type spraying can reduce the high temperature effect. Jackson (1938) showed that at temperatures above 83°F. the use of a swine wallow increased appetite, rate of gain and efficiency of feed utilization. Culver et al. (1960) reported that in two of three experiments, a mist-type spray significantly ($P < 0.01$) increased rate of gain. Swine having access to a mist-type spray showed no appreciable rise in either respiration rate or rectal temperature over a range of 73° to 88°F. in ambient temperature. Heitman et al. (1959) compared the different cooling methods. The groups compared included wallow, shaded wallow, fanned wallow, air-conditioned house, and indoors. They found all the treated groups gained weight more

rapidly (1.43 to 1.51 pounds per day) than the control (1.30 pounds per day) but there was no significant difference between treatments. Food utilization appeared to be poorest in the control group and best in the group with access to the air-conditioned house.

The absorption of heat from sunlight is less in the case of animals with light-colored coats than in the case of those with dark coats. Heitman and Hughes (1949) reported that increasing the relative humidity from 30 to 90 percent had little effect upon body temperature but did cause an increase in respiration rate.

Performance Differences Due to Breed

In addition to the differences in carcass quality some other traits were found to vary in different breeds. Lush and Molln (1942) compared eight breeds of hogs for litter size at birth and weaning weight of the litter. They found highly significant differences between the breeds for each of these characteristics. Bradford et al. (1953) studied performance by measuring number farrowed, number raised to 5 months and litter weight at 5 months, between spotted Poland China, Duroc, Chester White, Poland China and cross bred. The result of analysis of variance showed that significant differences did exist between individual breeds. The Poland China's were significantly inferior to each of the other three breeds. Among the other three breeds, the Spotted Poland China gilts farrowed fewer pigs than did the Duroc

and Chester White ($P < .05$).

Aunan et al. (1960) conducted an experiment to find the influence of level of dietary protein on live weight gains. Besides finding the significant protein level effect, they also found a significant difference ($P < .05$) in daily gain up to 125 pounds due to breed. This breed difference increased during the period from 125 to 200 pounds. Analysis of the data for the entire experiment showed the difference to be highly significant ($P < .01$).

In order to compare the growth rates in different stages the heredity of gain in different growth periods has been reviewed.

Hazel et al. (1943) studied the genetic and environmental correlations between growth rates of pigs at different ages and reported that heredity played a smaller, but more constant part in controlling gain than did the environmental factors. Hazel et al. and Blunn et al. (1954) studied the heritability estimates of gain in the three periods; birth to weaning (56 days), 56-112 days, and 112-154 days, based on parental half-sib relationship and found an average heritability of .13, .38 and .25 for the respective periods. The multiple regression based on growth in each period was .772 (average from 2 results). Blunn indicated that the gain from 56 to 112 days of age could be used satisfactorily for selection for growth rate.

Forchow et al. (1955) reported that there was a correlation

of 0.46 between weaning weight and birth weight ($P < 0.01$). On the average, a difference of 1 pound in weight at birth was accompanied by 7.78 pounds difference at weaning (56 days).

Based on the whole sib, Blunn (1954) reported that the average within-litter correlations were birth-weaning weight 0.53, birth-154-day weight 0.40, and 56 day-154-day weight 0.63. The coefficient of determination (r^2) of the 56-day weight on 154 day weight is .40 indicating that a knowledge of 56-day weight accounts for only 40 percent of the variance in 154-day weight. Selecting heavy pigs at 56-days in order to increase weight at 154-days can thus be expected to have only a low efficiency. However, the relationship between total litter weights at 56 and 154 days of age is high.

Craig et al. (1956) reported that indirect selection for heavy weights at 154 or 180 days of age on the basis of birth, 21 or 56 day weights would be approximately 0, 20, or 50 percent as effective respectively, as direct selection for heavy 154- or 180-day-weights.

Craig also found that sex had a significant effect on weight at all ages. It caused progressive absolute weight differences in favor of the boars ranging from 0.134 pounds at birth to 4.5 pounds at 180 days (5% at birth, 3% at 180 days).

EXPERIMENTAL PROCEDURE

The animals used in this study were among those tested at the Kansas Swine evaluation station during the past three

years. The first test group was started during the fall of 1958 and since that time, six groups of animals have been fed at the station. The number[1] and breeds of pigs tested in each group are listed below:

Year	58	59		60		61	
Season	Fall	Spring	Fall	Spring	Fall	Spring	TOTAL
Breeds							
Duroc	23	22	3	18	14	29	109
Hampshire	35	32	3	18	14	34	136
Yorkshire	14	16	6	23	18	22	99
Landrace	9	9	2	6	15	3	44
Berkshire	12	10	3	2	5	3	35
Poland C	3	6	3	3	-	4	19
Spotted PC	3	4	-	9	9	6	31
Tomworth	3	-	-	-	-	-	3
TOTAL	102	99	20	79	75	101	476

[1]not including the pigs which didn't meet minimum production standards.

The data collected were summarized and analyzed for this study. These were purebred animals and it was required that they meet certain requirements before they could enter the testing station. Each entry included three litter mates, two boars and one barrow or two litter mate boars and a half-sib barrow. Boar pigs were eligible for registry in a breed association and each had at least 12 functional nipples. In order to standardize conditions so that results would be comparable pigs were required to weigh between 45 and 60 pounds upon arrival at the station. Normally pigs farrowed between January and March made the spring test and pigs farrowed between July and September made the fall test. All of the pigs had been certified by the local veterinarian to show that they had been vaccinated for

cholera and erysipelas, had been blood tested for leptospirosis and brucellosis and were apparently free from communicable disease.

Weights were recorded when the pigs arrived at the station. Usually it took about four days to one week for the pigs to adjust to the station and the rations before they could go on test. Pigs were placed on test when they weighed between 55 and 65 pounds.

The two boars in an entry were penned together and self-fed. They were weighed on the same day weekly and average daily gain and weekly gain were measured from the start of the test until each boar weighed 200 pounds. Upon the finish of the daily gain and feed efficiency test, boars were probed to determine the average backfat thickness. The probing sites were, at the fifth rib, at the last rib, and at the last lumbar vertabrae. All three probes were made 1 1/2 to 2 inches off the midline. The minimum requirements for the tested boars were as follows:

a. Overall index of 100 or more
b. Average daily gain of 1.50 pounds or more
c. Average feed efficiency of 3.25 pounds or less
d. Average backfat thickness of 1.50 inches or less

The formula used to calculate the index on each boar gives equal weight to average daily gain, average backfat thickness and average feed efficiency. This formula is:

240 + (rate of gain x 50) - (feed efficiency x 50) - (backfat x 50) = index

After completion of each test the boars were sold at public auction.

Barrows from all entries were penned together and self-fed. Feed efficiency was not determined for individual barrows. They were weighed on the same day weekly and average daily gain was measured from the start of the test until each barrow weighed approximately 210 pounds. Each week those which had reached approximately 210 pounds live weight were probed (same procedure as boars) and then slaughtered. The pigs were deprived of feed but allowed access to water for 14 hours before slaughter. The carcasses were split after slaughter and were chilled for 48 hours at a temperature of approximately 37°F. Carcass length was measured from the first rib to the anterior edge of the aitch bone. Carcass backfat thickness was measured on both sides of the split carcass at the first rib, last rib and the last lumbar vertebra. The average of the measurements was designated as average of six carcass backfat measurements. Percent lean cuts was computed by dividing the sum of the weights of the closely trimmed hams, loins, Boston butts, and picnic shoulders by the chilled carcass weight and multiplying by 100. Loin eye area was measured at the tenth rib on the right side.

The ration used for feeding both boars and barrows was as follows:

KANSAS SWINE TESTING RATION
(Prepared in University Feed Mill)

Sorghum grain	1544 lbs.
50% Tankage	60 lbs.
44% Soybean Oil Meal	200 lbs.
60% Fishmeal	40 lbs.
17% Dehydrated Alfalfa Meal	60 lbs.
Cane molasses	50 lbs.
Iodized Salt	10 lbs.
Dicalcium Phosphate	15 lbs.
Calcium Carbonate	8 lbs.
Trace Minerals (5% Zinc)	1 lb.
B-complex Vitamins (Merck 58-a)	2 lbs.
Vitamin A (10,000 I.U. per gram)	200 grams
Vitamin D (3,000 I.U. per gram)	100 grams
* Vitamin E (20,000 I.U. per lb.)	1 lb.
Aurofac 1.8-1.8	5 lbs.
* Arsanilic Acid (Pro-Gen)	1 lb.
* DL-Methionine	2 lbs.
* Lysamine (20% lysine)	2 lbs.

*Not included in fall of 1958 or spring of 1957.

Approximate analysis: 16% crude protein; 0.75% calcium; 0.62% phosphorus.

This ration is fed to boars and barrows until they weigh 200 pounds. The boars are taken off test at 200 pounds and carried on a high fiber ration (15% alfalfa) until sale time.

The barrows are taken off test at approximately 210 pounds body weight, shrunk overnight and slaughtered. Arsanilic acid is removed from the barrow ration prior to slaughter as per F.D.A. regulations.

The ration is pelleted and self-fed at all times.

All six groups of pigs were used in studying differences in performance due to years, season and breeds. For the temperature influence on the daily gain only pigs from the fall test of 1960 and the spring test of 1961 were used in studying the effect of temperature upon daily gain. The temperature data were collected and recorded by Dr. Dean Bark of the K.S.U. Physics Department.

RESULTS AND DISCUSSION

As previously mentioned, this study was made in an effort to determine differences in performance by measuring several traits. Environmental influence on the traits studied was also measured. In addition to these, the correlations between backfat thickness and the several traits such as feed efficiency, daily gain, and age to 200 pounds were also studied in an effort to determine whether meatier hogs have higher feed efficiency or a faster rate of gain.

All the data collected from the boars and barrows raised in the test station during the three years were analyzed. The analysis of variance was used in order to detect differences that were due to the effect of year, season, breed or neither of these. Turkey's LSD method was used to determine the significant difference between breeds when the breed effect in the analysis of variance was significant at higher than the 0.05 level. A graph was used to illustrate the seasonal effect when it was shown that there was a significant difference between the spring and

fall seasons. Correlation coefficients were computed to determine the relationship between backfat thickness and the several performance traits, also to determine the relationship between boar sale price and feed efficiency, backfat thickness, daily gain, age to 200 pounds and index.

All the data were correlated and classified according to season and year.

Seasonal Effect and Difference Between Breeds in Average Daily Gain

Some of the pigs tested in the fall of 1958 started at heavier weights than those in other tests and those pigs were excluded from this study. When the analysis of variance was applied to the daily gain data of boars a significant ($P < .05$) difference between seasons was found. It was shown that the major breeds, Duroc, Hampshire, Yorkshire and Poland China, gained faster in the spring season than in the fall season. If breed was disregarded the average daily gain in the spring season was 0.048 pounds higher than in fall season. A significant difference in daily gain of breeds was only found at the 0.1 percent level. Turkey's LSD was used to test the significant differences between the individual breeds and it was found that the Duroc breed had a significantly higher daily gain than the Spotted Poland China, Poland China, Landrace, Hampshire and Yorkshire breeds. No significant differences were found between other breeds. The greatest difference was 0.187 between the Duroc and

the Spotted Poland China breeds (Appendix Table 1, Table 2 and Figure 1).

Probably due to the fact that all of the barrows in each test were penned together the identical environmental conditions reduced the variation existing among individuals. Consequently a highly significant ($P < .01$) difference in average daily gain between breeds and significant difference between years and between seasons ($P < 0.05$) was indicated from the analysis of variance. Duroc barrows showed a significantly higher daily gain than the other breeds except in the case of Berkshires. Berkshires and Poland Chinas respectively, made a significantly higher daily gain than Hampshires. (Appendix Table 3, Table 4, and Figure 2).

Seasonal effect on daily gain was found to be significant at the 0.05 level. Spring pigs gained faster than fall pigs. However, from tests made on individual breed data it was concluded that only Hampshire barrows showed a significant seasonal effect. This result did not agree with Stevenson et al. (1960) who reported that pigs gained faster in the winter time than in the summer time. Possibly differences in climate and other environmental conditions between Beltsville and Kansas influenced the results reported.

As mentioned above there was a significant difference in daily gain between breeds in the case of both boars and barrows. However, in no case was there a significant difference in age to 200 pounds between breeds. (See Appendix tables 5, 6, 7 and

and 8 and Figures 3 and 4). The Duroc breed gained faster during the test, but the average age started on test was 10, 6, or 14 days older than Hampshire, Yorkshire or Landrace respectively. The average initial testing weight in all cases was around 60 pounds. Possibly this difference in age on test was due to poorer milking ability of Duroc sows or other genetic factors. Season effects were found to be significant in the case of boars but not in the case of barrows. However both graphs (Figure 3 and 4) show that there was a difference in the age to 200 pounds between spring and fall farrowed pigs for both boars and barrows especially in the case of the major breeds studied (Duroc, Hampshire, Yorkshire and Poland China). If breed is disregarded the spring boar pigs required an average of 3.7 days less than the fall pigs and the spring barrows required an average of 6.7 days less than fall fed barrows to reach 200 pounds. The difference was higher in Hampshire breed in both sexes than in other breeds.

Ambiant Temperature Influence on Daily Gain

Three major breeds including Duroc, Hampshire and Yorkshire were studied further in order to explain differences in age to 200 pounds. Figure 5, the comparison of daily gain of spring pigs and winter pigs shows that the spring pigs did not have a faster gain from the beginning of test to the sixth week on test. However, after the sixth week, the curves show that there was an apparent difference in average daily gain between seasons. The

spring pigs gained an average of 2.205, 2.180, 2.130 and 2.023 pounds in the 7th, 8th, 9th and 10th week after being placed on test. On the other hand, the fall pigs gained only an average of 1.877, 1.943, 1.933 and 1.924 in the same periods.

Several reports have indicated that ambiant temperature influenced the feed efficiency. It is possible that the ambiant temperature might also influence daily gain. Most of the fall pigs in this study were put on test from the middle of October to the first part of November. The first week on test to the sixth week on test included the period from about October to mid December. The average daily temperatures in late October, November and the first part of December were 52°F, 43°F, and 32°F respectively. After mid December, the average temperature was always below the freezing point. The average for late December and January, was 28°F and 27°F respectively. From this study it appeared that an average temperature above 32°F would not influence daily gains. However, the 32°F appeared to be a critical temperature for the growing animals. When the average temperature dropped below 32°F animals apparently gained slower because they had to use more available energy to produce heat for the maintenance of a constant body temperature.

During the summer time, since the mist-spray was used to lower the temperature, it was not possible to determine whether a higher ambiant temperature influenced the daily gain of spring pigs. However, the summer daily gain curve showed that the average rate of gain increased until the eighth week and after

that the curve turned downward. The average ambiant temperature in June and July was about 73-75°F. The spring pigs had been on test eight to nine weeks at that time. That temperature is higher than the critical temperature for swine (68°F.) reported by Ritzman. Pigs made greatest gains at the seventh and eighth week on test when the ambiant temperature was around 60°F. This agrees with Hertman (1951) who reported that the optimum temperature for heavier hogs was about 61°F.

Since the humidity fluctuation is usually relatively small in Kansas, no attempt was made to study its influence on the average daily gain.

Two graphs (Figure 6 and 7) were prepared to show both daily gain and growth curves of the different breeds. Figure 6 shows that three breeds (Duroc, Hampshire and Yorkshire) didn't differ significantly in growth rate up to the fourteenth day on test. The difference in growth rate seemed to occur after they had reached 100 pounds in body weight. Figure 7 shows that the Hampshire breed showed more fluctuation in daily gain during testing than the other two breeds especially when compared with Duroc's. As mentioned previously, however, both Hampshires and Yorkshires made greater gains than Durocs before going on test since the latter breed took longer to reach the average initial testing weight of 60 pounds (See Table 9 and 10).

Seasonal Effect and Difference Between Breeds on Feed Efficiency

Since the barrows were penned together, only the pairs of boars were used to study feed efficiency. The data was computed on a pen basis. The average feed efficiency listed in Tables 11 and 12 indicates the total feed intake per 200 pounds of gain. The fall test of 1958 was not included in this study.

The analysis of variance, showed that there was a highly significant difference in the feed efficiency between seasons. The graph in Figure 8 showed that all the breeds apparently had a better feed efficiency during the spring season. Disregarding breed there was a difference of 30.50 pounds of feed for each 200 pounds of gain between the spring season and the fall season. This is in agreement with Stevenson et al. (1960) who indicated that the winter fed pigs ate more feed than the summer fed pigs.

No significant difference was found in the feed efficiency between breeds, although Table 12 showed that the Duroc breed had a better feed efficiency than other breeds. The difference was 30.4, 31, 27.2, 31.5 between Duroc and Poland China, Landrace, Berkshire, and Spotted Poland China respectively.

Seasonal Effect and Difference Between Breeds in Live-hog Backfat Thickness

Significant ($P < .05$) differences in backfat thickness between breeds in the case of barrows were found (The number of

barrows was less than one half of the number of boars). Among boars, the Duroc breed had a significantly higher backfat thickness than any of the other breeds studied. However, no significant differences were found among the other breeds. Spotted Poland China's had the lowest backfat thickness among the breeds. The difference between Spotted Poland China's and Durocs was 0.156 inch. Berkshire ranked next to Spotted Poland Chinas. In the case of barrows, Durocs also had greater backfat thickness than any other breed. Due to the fewer members studied than was the case with boars, only Landrace, Spotted Poland China, and Hampshire barrows were found to be significantly lower in backfat thickness than Duroc barrows. In addition to this, Landrace did have significantly less backfat than Yorkshire and Poland China, and Hampshire had significantly less backfat than Yorkshire. In the case of barrows, Landrace had the lowest backfat thickness among the breeds studied and Spotted Poland China ranked next to Landrace. Appendix tables 13, 14, 15 and 16 and Figure 9 illustrate the results of backfat measurements.

The above mentioned findings agree with Aunan et al. who indicated that there was a highly significant difference in backfat thickness between breeds. Also, this study definitely indicated that the Duroc breed both in the case of boars and barrows had a higher backfat thickness than any other breed.

Seasonal effects were found in the case of barrows but not in the case of boars. For the three major breeds of barrows, Hampshire and Yorkshire had higher backfat thickness in spring

than in fall. The differences were significant at the .05 level. This finding did not agree with Stevenson who reported that the winter fed hogs had thicker backfat than the summer fed hogs. These findings will be discussed later along with a discussion of a significant negative correlation between backfat thickness and age to 200 pounds and a significant positive correlation between backfat thickness and daily gain which will be discussed later. It seems well to mention again here that the age to 200 pounds was found to be significantly less in the spring than in the fall. Feed efficiency was found to be poorer in the fall than in the spring while daily gain was higher in spring farrowed pigs.

Many researchers have already indicated that there is a high correlation between carcass backfat thickness and the live hog backfat thickness. Therefore, no study was made in that area.

Seasonal Effect and Difference Between Breeds in the Carcass Length, Percent of Lean Cuts, and Loin Eye Area of Barrows

One hundred and fifty barrow carcasses were studied and it was found that there was a highly significant difference ($P < .01$) in carcass length between breeds and between seasons. Landrace had significantly longer carcass's than any other breed. Poland China's were the shortest in carcass length in this study. Yorkshire ranked second longest to Landrace and significantly longer than the remaining breeds. Poland China's were significantly shorter in carcass length than any other breed except Spotted

Poland China. Seasonal effect varied from breed to breed. Duroc, Hampshire, and Spotted Poland China had greater carcass length in the spring season than in fall (see Tables 17 and 18 and Figure 10).

The analysis of variance failed to show a significant difference in the percentage of lean cuts between seasons or breeds. A significant difference ($P < 0.05$) was found between years (See Tables 19 and 20).

There was more variation between individuals within breeds in the loin eye area than between breeds. Through the analysis of variance, a highly significant difference was found between seasons. Figure 11 shows that the spring pigs had larger loin eye area than the fall pigs. Spotted Poland China's and Poland China's had larger loin eye area than other breeds. It appeared that among breeds the shorter breeds had the larger loin eye area. The Poland China breed was significantly shorter in carcass length than any other breed except Spotted Poland China. The Spotted Poland China was significantly shorter than Landrace, Yorkshire and Hampshire (see Tables 21 and 22 and Figure 11).

Correlation Between the Live Probe Measurements of Backfat Thickness

Individual live probe measurements for backfat were compared to the average of the backfat thickness for six probe readings and correlation coefficients were as follows:

Trait	First site (behind shoulder)	Second site (last rib)	Third site (last lumbar vertabrae)	Average backfat thickness
	X_1	X_2	X_3	X_4
X_1	--	.733	.707	.880
X_2		--	.780	.906
X_3			--	.932

All of the above correlation coefficients are highly significant. The third probe measurement (last lumbar vertebrae) had the highest correlation with the average backfat thickness. This agrees with the results reported by Missouri workers (1958) who found the highest correlation coefficient between the third measurement and the percentage of carcass fat, but does not agree with Iowa results (1953, 1958, 1959).

The highly significant correlation coefficient between the third measurement and the average of six measurements suggests that the third measurement can be used with equal accuracy to predict the carcass backfat.

Correlation Between Backfat Thickness, Feed Efficiency, Daily Gain, Age to 200 Pounds

An attempt was made to relate certain performance traits, sale price and index for the boars studied. Table 23, a through b, shows the correlations between the various items both on an individual breed basis and on a total basis.

Several researchers have concluded that the meatier hog has a better feed efficiency, has a faster daily gain and goes to slaughter at an earlier age than the fatter hog. However, except

in the case of the Berkshire breed, the reverse was true in this study. Durocs and Berkshires showed a positive correlation between feed efficiency and backfat thickness. The correlation in the Berkshire breed ($r = .689$) was significant at the 5 percent level. The other five breeds showed negative correlations. Significant correlations were found in Landrace breed ($r = -.954$, $P < .01$) and in Yorkshire breed ($r = -.318$, $P < .05$). If breed is disregarded, the correlation was -.175 at the 0.05 significance level.

Highly significant correlations between backfat thickness and daily gain were found in Duroc, Hampshire, Yorkshire, Spotted Poland China and over all (disregarding breed). ($r = .454$, .508, .378, .739, .465 respectively). Only the Berkshire breed showed a negative correlation ($r = -.292$) and that was not at a significant level.

Negative correlations existed between the backfat thickness and age to 200 pounds in all breeds except the Berkshire breed. In the case of the Duroc breed, the correlation was highly significant ($r = -.372$). In the case of the Landrace breed, it was at the 0.05 significance level ($r = -.696$). For the overall study, the negative correlation ($r = -.208$) was at the .05 significance level.

From these correlation coefficients between backfat thickness and the other three performance traits, it appears that breed is a factor in determining whether the meatier hog has better feed efficiency, higher daily gain, or is younger at 200 pounds body

weight than the fatter pig. In most breeds studied however, the animal with a greater backfat thickness was better in feed efficiency, faster in daily gain and younger in age to 200 pounds. Analysis of data available for barrows closely related to the boars gave further evidence for the above conclusion.

Data available made it impossible to determine definitely whether faster gaining pigs have a better feed efficiency than slower gaining pigs. However, the negative correlation coefficient for Landrace, Berkshire, and Spotted Poland China ($r = -.378$, $-.346$ and $-.47$ respectively) suggests that the faster gaining pigs in those breeds had the best feed efficiency although the number of hogs for each of the three breeds was not enough to test the correlation coefficients for significance. Because there was a very low correlation existing between feed efficiency and daily gain in the case of the Duroc, Hampshire and Yorkshire breeds ($r = -.15$, $-.052$, and $.054$ respectively) it is suggested that the relationship between the two traits in those three breeds is small.

Duroc, Hampshire, Landrace, Yorkshire, and Berkshire breeds showed highly significant (-.524, -.576, -.865, -.479 and -.787 respectively) negative correlations between the daily gain and age to 200 pounds. Since the daily gain was computed by dividing total pounds gained by the days on test, the varying correlations between the above two traits during the on test time indirectly indicates that pig performance before reaching the on test weight of 60 pounds was more uniform in some breeds than in others.

Correlation Between the Sale Price and the Performance Traits

The analysis of variance indicated that the sale price was significantly different between years, between seasons as well as between breeds (Tables 24 and 25 - Figures 12 and 13). The average sale price showed a rise each year in the years studied. Probably educational promotion by interested persons helped increase interest in the use of tested boars and this in turn increased demand for them. An improving pork market is another probable reason for increased interest in the use of tested boars for herd improvement. Farmers paid higher prices at the fall sales than they did at the spring sales. Probably this was due to the fact that more sows were bred in the fall in order to have them farrowing the next spring. Yorkshire boars sold higher than other breeds in the sales.

The correlation coefficients between the sale price and index, feed efficiency, daily gain, age to 200 pounds, and backfat thickness indicated that the index is the main reference used by farmers in their selection of boars. Among the individual traits, farmers placed more emphasis on feed efficiency of the Duroc than for other breeds. More emphasis was placed on daily gain in the case of Hampshires, Yorkshires, and Berkshires, than upon any other trait.

Conclusion

In conclusion it may be stated that the findings of this study revealed three things of importance:

1. Seasonal effects influence certain swine performance traits; daily gain, feed efficiency, live animal fat back thickness, age to 200 pounds as well as carcass length and loin eye area. However, this seasonal effect apparently varies from breed to breed and also by sex. All the breeds had a better feed efficiency during the spring season. For the four major breeds studied (Duroc, Hampshire, Yorkshire and Poland China) the boars showed faster gains in spring but this was not true for the barrows. Yorkshires and Hampshires were higher in backfat thickness, lower in the percent of lean cuts and smaller in loin eye area in the spring. In the Duroc breed, the barrows were higher in backfat thickness shorter in carcass length and had a lower percentage of lean cuts and a larger loin eye area in the fall than in the spring. Ambient temperature was one of the factors apparently involved in the seasonal effect on growth rate. Below 32°F the daily gain was apparently decreased. Between 32° to 45°F it appeared that only feed efficiency was influenced. Since the same feed was fed in both seasons, any dietary effects would be indirect as a carryover from previous nutrition.

Generally speaking, the spring pigs showed better performance in growth rate, feed efficiency and earlier age to 200 pounds body weight. Carcasses from spring pigs were longer in

carcass length and smaller in loin eye. No significant difference was found in the percent of lean cuts.

2. Breed differences were found in studying the traits of backfat thickness, daily gain (for boars, this difference was significant at the 0.1 level), feed efficiency, and carcass length. The Duroc breed gained faster, had better feed efficiency (not at a significant level), had significantly higher backfat thickness, and a relatively lower percentage of lean cuts than other breeds. The testing records showed that the Duroc breed took more days to reach the initial testing weight (Average 60 pounds). This might indicate that the Duroc breed does not have as much milking ability as other breeds or possibly the Duroc breed has genetic factors causing slower growth during the early life stage. The Landrace breed was significantly longer in carcass length, higher in the percentage of lean cuts and lower in backfat thickness than other breeds. The Yorkshire breed ranked second to the Landrace breed in carcass length and was significantly longer than other breeds. Both Poland Chinas and Spotted Poland Chinas were shorter in carcass length but were larger in loin eye area (not significant) than other breeds. No significant difference was found in the age to 200 pounds between breeds, although the Duroc breed required a few days less than other breeds. This lack of difference might be due to the fact that the Duroc pigs took more days to reach the on test weight but gained faster than other breeds during the test period.

3. The significant negative correlation between backfat

thickness and age to 200 pounds in Duroc and Landrace boars, and the significant positive correlation between backfat thickness and daily gain in Duroc, Hampshire and Spotted Poland China boars studied indicated that those gaining most rapidly and reaching 200 pounds at the earliest age within these breeds have greater backfat thickness. Both long-carcass-length breeds, Landrace and Yorkshire, showed a significant negative correlation between backfat thickness and feed efficiency. In the Berkshire breed, the positive correlations between the backfat thickness and feed efficiency ($P < .05$ $r = .689$), and between backfat thickness and age to 200 pounds (not significant, $r = .393$), and the negative correlation (not significant, $r = -.292$) between backfat thickness and daily gain indicated that within the Berkshire breed, meatier pigs would gain faster, reach 200 pounds at an earlier age and have poorer feed efficiency. There was also a positive correlation ($r = .138$) between backfat thickness and feed efficiency in the Duroc breed but it was not significant. The facts mentioned above complicate the task of selecting for faster gain, better feed efficiency, earlier age to 200 pounds, and lowered backfat all at the same time. Breed differences should be considered when practicing selection for the various desirable characteristics.

In the Berkshire breed, it would appear to be more simple to select for all of these desirable characteristics at once. However, in the other breeds it would appear to be more difficult.

The comparatively lower correlation between daily gain and age to 200 pounds in Duroc and Yorkshire breeds suggests that the performance of individuals in these two breeds is more variable than in other breeds.

The higher correlation ($r = -.663$) (all breeds together) between the index and feed efficiency than between index and daily gain ($r = .335$) or backfat thickness ($r = -.321$) indicated that more emphasis has been put on feed efficiency than on other factors. However, higher correlation was found between the price with daily gain than with feed efficiency or backfat thickness. This indicated that the breeders and farmers had emphasized daily gain more than other traits when buying boars. Probably, a further study should be made to determine whether we should give more credit to the daily gain in the index used at this testing station.

SUMMARY

The weekly weights, live hog backfat thickness, feed efficiency and carcass records for seven breeds including three hundred and sixteen boars and a hundred and fifty-seven barrows from six separate test groups over a three year period were studied for the purpose of determining seasonal effects on hog performance. The differences in performance between breeds and the relationships between backfat thickness, feed efficiency, daily gain, age to 200 pounds sale price, and index were also

studied. In each testing period all the boars and barrows were raised under the same management and fed the same feed except that the barrows were penned together while each pair of litter mate boars was raised together in a pen. The average initial testing weight was 60 pounds. Pigs were weighed weekly until reaching 200 pounds. Backfat thickness was measured in three places; over the 5th rib, over the last rib and over the last lumbar vertebrae when boars weighed 200 pounds. Measurements were averaged to obtain average backfat thickness. When each of the litter mate boars weighed around 200 pounds, the feed efficiency was calculated based on the amount of feed intake per 200 pounds of gain during the test period. Average daily gains were determined by dividing total gain by days on test. Barrows were slaughtered at approximately 200 pounds body weight and the carcass length, percentage of lean cuts and loin eye area were determined. By using the analysis of variance, the seasonal effects and the differences existing between breeds were found as follows:

The feed efficiency for boars was found to be significantly better in spring than in fall ($P < .01$). In the comparison of seasonal effects within individual breeds, Yorkshire showed highly significant differences due to season and Durocs showed significant differences due to season. The difference in feed efficiency between seasons averaged 30.50 pounds of feed per 200 pounds of gain. No significant difference in feed efficiency between breeds was found although the Duroc breed had better efficiency than other breeds.

Daily gain was found to be significantly higher in the spring ($P < .05$). However, in the comparison within individual breeds this was only found significant for the Duroc breed. Durocs were found to be older at the initial test weight (60 pounds) but they also gained significantly faster after going on test and reached 200 pounds sooner than other breeds. Spring boar pigs reached 200 pounds at an earlier age than fall boar pigs ($P < .05$). Within individual breeds a significant seasonal effect was found for Hampshires and Durocs. No significant seasonal effect upon barrows and no significant difference between breeds was found.

Significant differences in backfat thickness between breeds was found in both boars ($P < .01$) and barrows ($P < .05$). The Duroc breed had significantly higher backfat thickness than any breed in the case of boars and higher than Landrace, Spotted Poland Chinas and Hampshires in the case of barrows. Significant seasonal effect was found in the case of barrows ($P < .05$). Spring barrows had more backfat than the fall barrows. Within individual breeds, this effect was found highly significant ($P < .01$) for Yorkshire barrows.

Yorkshires were second in carcass length to Landrace and both were significantly longer than any other breed studied. Poland Chinas and Spotted Poland Chinas were comparatively shorter than other breeds. Overall, the difference in carcass length between breeds was highly significant ($P < 0.01$). Spring pigs were longer in carcass length than fall pigs. Within individual

breeds, this was found to be highly significant ($P < 0.01$) in Hampshire, significant ($P < 0.05$) in Durocs and Poland Chinas. However, no significant seasonal effect was found in other breeds.

Season had a highly significant effect on loin eye area when all barrows were studied as a group. In analyzing data from barrows of each breed separately season showed no effect in the case of Poland Chinas and only in the case of Yorkshires was it significant.

Neither seasonal effect nor breed differences were found in the case of percent of lean cuts.

Ambiant temperature effect was studied and it appeared that below 32°F the temperature apparently influenced the daily gain and the feed efficiency.

The study of correlation coefficients between the backfat thickness and feed efficiency, daily gain and age to 200 pounds, indicated that except for the Berkshire breed, pigs higher in backfat thickness would have better feed efficiency. In the case of the Berkshire breed, those lower in backfat thickness were better in feed efficiency ($r = .689$ $P < .05$). These results indicate that the selection work for these traits should be made on an individual breed basis. One could not expect to have less backfat thickness with better feed efficiency, and faster daily gain by simply selecting on the basis of backfat thickness in most breeds.

The correlation between daily gain and feed efficiency was relatively low and no significant results were found. The

correlations between daily gain, time on test and age to 200 pounds were all significant but varied from breed to breed. Duroc and Yorkshire were comparatively low possibly because of more variation between individual pigs in daily gain before going on test, in these two breeds.

The comparatively high correlation coefficient between sale price and daily gain (over all breeds $r = .317$ $P < .01$) indicated that the breeders put more emphasis on the daily gain than on the backfat thickness ($r = -.165$ $P < .05$), age at 200 pounds ($r = -.197$ $P < .01$) or feed efficiency ($r = -.086$ not significant).

The highly significant correlation ($r = .93$ $P < .01$) between the middle loin (last lumbar vertebrae) backfat measurement and the average of the three measurements (behind shoulder, last rib and middle loin) suggests that the single backfat measurement on the middle loin (last lumbar vertebrae) would be as accurate as the three measurements averaged.

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LITERATURE CITED

Aunan, W. J., L. E. Hanson and R. J. Meade.
Influence of level of dietary protein on live weight gains and carcass characteristics of swine. J. Animal Sci. 19: 1036. 1960.

Blunn, Cecil T., Guy N. Baker and L. E. Hanson.
Heritability of gain in different growth periods in swine. J. Animal Sci., 12: 39. 1953.

Blunn, Cecil I., Everett J. Warwick and James R. Wiley.
Interrelationships of swine weights at three ages. J. Animal Sci., 13:383. 1954.

Bohman, V. R., J. E. Hunter and J. A. McCormick.
The effect of graded levels of alfalfa and aureomycin upon growing-fattening swine. J. Animal Sci. 14:499. 1955.

Bradford, G. E., A. B. Chapman and R. H. Grummer.
Performance of hogs of different breeds and from straightbred and crossbred dams on Wisconsin farms. J. Animal Sci. 12:582. 1953.

Bradford, G. E., A. B. Chapman and R. H. Grummer.
Time of farrow and performance in spring farrowed pigs. J. Animal Sci., 12:848. 1953.

Bratzler, L. J. and E. P. Margerum.
The relationship between live hog scores and carcass measurements. J. Animal Sci. 12:856. 1953.

Bratzler, L. J., R. P. Soule, E. P. Reineke and Pauline Paul.
The effect of testosterone and castration on the growth and carcass characteristics of swine. J. Animal Sci. 13:171. 1954.

Bruner, W. H.
Meat hogs take less feed. National Hog Farmer. Oct. 1958.

Craig, James V., Norton, H. W. and S. W. Terrill.
A genetic study of weight at five ages in Hampshire swine. J. Animal Sci. 15:242. 1956.

Crampton, E. W., G. C. Ashton and L. E. Lloyd.
Improvements of bacon carcass quality by the introduction of fibrous feeds into the hog finishing ration. J. Animal Sci. 13:327. 1954.

Culver, A. A., F. N. Andrews, J. H. Conrad and T. L. Noffsinger.
Effectiveness of water sprays and a wallow on the cooling and growth of swine in a normal summer environment. J. Animal Sci. 19:421. 1960.

Deighton, Thomas.
A study of the metabolism of two breeds of pigs. J. Agr. Sci. 19:141. 1929.

De Pape, J. G. and J. A. Whatley.
Live hog probes at various sites, weights, and ages as indications of carcass merits. J. Animal Sci. 15:1029. 1956.

Dukes, H. H.
The physiology of domestic animals. Seventh edition.

Forshaw, R. P., Helen M. Maddock, Paul G. Homeyer and Damon V. Catron.
The growth of Duroc suckling pigs raised in drylot. J. Animal Sci. 12:263. 1953.

Hankins, O. G. and R. L. Hiner.
A progress report on the meat yields of Danish Landrace hogs in comparison with certain American breeds. Proc. Am. Soc. An. Prod. 255. 1937.

Hazel, L. N. and E. A. Kling.
Mechanical measurement of fatness and carcass value on live hogs. J. Animal Sci. 11:312. 1952.

Hazel and E. A. Kline.
Ultrasonic measurement of fatness in swine. J. Animal Sci. 18:819. 1959.

Heitman, H. Jr. and E. H. Hughes.
The effect of air temperature and relative humidity on the physiological well being of swine. J. Animal Sci. 8:171. 1949.

Heitman, Hubert, Jr., E. H. Hughes and C. F. Kelly.
Effects of elevated ambient temperature on pregnant sows. J. Animal Sci. 10:907. 1951.

Heitman, Hubert Jr., C. F. Kelly, and T. E. Bond.
The relation of ambient temperature to weight gain in swine. J. Animal Sci. 13:1021. 1954.

Heitman, H., C. F. Kelly and T. E. Bond.
Ambient air temperature and weight gain in swine. J. Animal Sci. 17:63. 1958.

Heitman, Hubert Jr., T. E. Bond, C. F. Kelly and LeRoy Hahn.
Effects of modified summer environment on swine performance. J. Animal Sci. 18:421. 1959.

Hetzer, H. O., O. G. Hankins, J. X. King and J. H. Zeller.
Relationship between certain body measurements and carcass characteristics in swine. J. Animal Sci. 9:37. 1950.

Hetzer, H. O., J. H. Zeller and O. G. Hankins.
Carcass yields as related to live hog probes at various weights and locations. J. Animal Sci. 15:257. 1956.

Hochstetler, L. N., J. A. Hoefer, A. M. Pearson and R. W. Luecke.
Effect of varying levels of fiber of different sources upon growth and carcass characteristics of swine. J. Animal Sci. 18:1397. 1959.

Holland, L. A. and L. N. Hazel.
Relationship of live measurements and carcass characteristics of swine. J. Animal Sci. 17:825. 1958.

Hudman, D. B. and E. R. Peo, Jr.
Carcass characteristics of swine as influenced by levels of protein fed on pasture and in dry lot. J. Animal Sci. 19:943. 1960.

Jackson, A. D., and F. Hale.
Fattening hogs need concrete wallow in hot weather. Progress Report, Texas Agr. Exp. Sta., 1938.

King, Steven C. and C. R. Henderson.
Variance components analysis in heritability studies. Poultry Sci. Vol. 33, No. 1: 147. 1954.

Kline, E. A. and L. N. Hazel.
Loin area at length and last rib as related to leanness of pork carcass. J. Animal Sci. 14:659. 1955.

Knopf, D. H., H. W. Bray, P. H. Phillips and R. H. Grummer.
Effect of protein level and quality in swine ration upon growth and carcass development. J. Animal Sci. 18:755. 1959.

Lush, J. L. and A. E. Molln.
Litter size and weight as permanent characteristics of sows. U.S.D.A. Tech. Bul. 836. 1942.

Merkel, R. A., R. W. Bray, R. H. Grummer and P. H. Phillips.
The influence of limited feeding, using high fiber rations, upon growth and carcass characteristics of swine.
1. Effects upon feed-lot performance. J. Animal Sci. 17:3. 1958.

Morrison, Frank B.
Feeds and Feeding. 22nd edition.

Noland, P. R. and K. W. Scott.
Effect of varying protein and energy intakes on growth and carcass quality in swine. J. Animal Sci. 19:67. 1960.

Pearson, A. M., J. F. Price, J. A. Hoefer, L. J. Bratzler and W. T. Magee.
A comparison of the live probe and lean meter for predicting various carcass measurements of swine. J. Animal Sci. 16:481. 1957.

Pearson, A. M.
Some simple cut indices for predicting carcass traits of swine. II. Supplementary measures of leanness. J. Animal Sci. 17:27. 1958.

Price, J. F., A. M. Pearson, H. B. Pfost and R. J. Deans.
Application of ultrasonic reflection techniques in evaluating fatness and leanness in pigs. J. Animal Sci. 19:381. 1960.

Price, J. F., A. M. Pearson and J. A. Emerson.
Measurement of the cross-sectional area of the loin eye muscle in live swine by ultrasonic reflections. J. Animal Sci. 19:786. 1960.

Robison, O. W., J. H. Cooksey, A. B. Chapman and H. L. Self.
Estimation of carcass merit of swine from live animal measurements. J. Animal Sci. 19:1013. 1960.

Snedecor, George W.
Statistical Methods. Fifth edition.

Speer, V. C., E. L. Lasley, G. C. Ashton, L. N. Hazel and D. V. Catron.
Protein levels for growing boars on pasture and concrete drylot. J. Animal Sci. 16:607. 1957.

Stevenson, J. W., R. J. Davey and H. L. Hiner.
Some effects on dietary levels of protein and alfalfa meal and of antibiotic supplementation on growth, feed efficiency and carcass characteristics in swine. J. Animal Sci. 19:887. 1960.

Teaque, H. S. and L. E. Hanson.
The effect of feeding different levels of cellulosic material to swine. J. Animal Sci.: 13:206. 1954.

Tidwell, A. L. and J. L. Fletcher.
The effect of summer environment on the body temperature and respiration rate of swine. J. Animal Sci. 10:523. 1951.

Winters, L. M., C. F. Sierk and J. N. Cummings.
The effect of plane of nutrition on the economy of production and carcass quality in swine. J. Animal Sci. 8:132. 1949.

Zimmerman, D. R., H. G. Spies, E. M. Rigor, H. L. Self and L. E. Casida.
Effect of restricted feeding, crossbreeding and season of birth on age at puberty in swine. J. Animal Sci. 19:687. 1960.

Zobrisky, S. E., D. E. Brady, J. F. Lasley and L. A. Weaver.
Significant relationships in pork carcass evaluation. V. Measurements and cuts of fat as criteria for live hog value. J. Animal Sci. 18:583. 1959.

Zobrisky, S. E., D. E. Brady, J. F. Lasley and L. A. Weaver.
Significant relationships in pork carcass evaluation. IV. Loin equivalents as a criterion for live hog value. J. Animal Sci. 18:594. 1959.

APPENDIX

Table 1. Seasonal effect and breed difference in average daily gain of boars.

Source of variation	Analysis of Variance d f	Sum or squares	Sum of mean sq.	F
Total	248	11.6114		
Years	2	0.0825	0.0412	0.9414
Seasons within years	2	0.3152	0.1576	3.6014 *
Breeds within seasons	28	1.7612	0.0629	1.4373
Individuals within breeds	216	9.4525	0.04376	

* Significant at 0.05 level.

Table 2. (a) Comparison of breeds on the basis of average daily gain of boars.

	No. of boars	Average initial wt.	Average daily gain pounds/day
Breeds			
Duroc	56	59.75	1.920
Hampshire	68	59.86	1.792
Yorkshire	57	61.00	1.822
Poland China	23	60.13	1.743
Landrace	15	61.86	1.778
Berkshire	11	62.81	1.791
Spotted Poland China	19	59.05	1.733
TOTAL	249	60.31	1.817

(b) Turkey's L.S.D. comparison

Breeds		Spotted Poland China	Poland China	Landrace	Berkshire	Hamp-shire	York-shire
	Average daily gain	1.733	1.743	1.778	1.791	1.792	1.822
Duroc	1.920	0.187 *	0.177 *	0.142 *	0.129	0.128*	0.098*
Yorkshire	1.822	0.089	0.079	0.044	0.031	0.030	
Hampshire	1.792	0.059	0.049	0.014	0.001		
Berkshire	1.791	0.058	0.048	0.013			
Landrace	1.778	0.045	0.035				
Poland China	1.743	0.010					

* Significant at 0.05 level

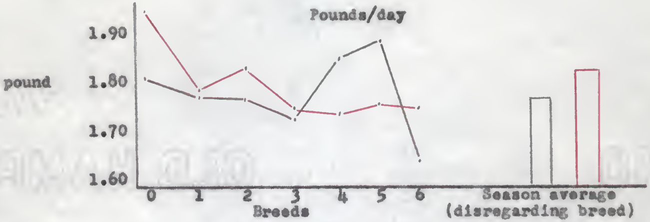

Figure 1. Seasonal effect on the daily gain of boars.

Number	Breed	Number of hogs: Fall	Spring	Total
0	Duroc	11	45	56
1	Hampshire	10	58	68
2	Yorkshire	16	41	57
3	Poland China	11	12	23
4	Landrace	5	10	15
5	Berkshire	2	9	11
6	Spotted Poland China	6	13	19
	TOTAL	61	188	249

Red line: Spring pig
Black line: Fall pig

Table 3. Season effect and difference between breeds in average daily gain of barrows.

Source of variation	Analysis of Variance d f	Sum of squares	Sum of mean sq.	F test
Total	24	5.4498		
Years	2	0.2887	0.14435	4.8225 *
Seasons within years	2	0.2434	0.12170	4.0658 *
Breeds within seasons	27	2.1340	0.07903	2.6403 **
Individual within breeds	93	2.7838	0.02993	

* Significant at 0.05 level
** Significant at 0.01 level

Table 4. Comparison of breeds on the basis of barrow average daily gain.

Breeds	No. of boars	Average daily gain pounds/day
Duroc	30	1.857
Hampshire	33	1.610
Yorkshire	28	1.701
Poland China	12	1.735
Landrace	8	1.688
Berkshire	5	1.836
Spotted Poland China	9	1.691
Total	125	1.716

(b) Turkey's L.S.D. comparison

Breeds		Hamp-shire	Landrace	Spotted Pol. C.	York-shire	Poland China	Berk-shire
	Average daily gain	1.610	1.688	1.691	1.700	1.735	1.836
Duroc	1.857	0.247*	0.169*	0.166*	0.157*	0.122*	0.021
Berkshire	1.836	0.226*	0.148	0.145	0.136	0.101	
Poland China	1.735	0.125*	0.047	0.044	0.035		
Yorkshire	1.701	0.091	0.013	0.010			
Spotted Poland China	1.691	0.081	0.003				
Landrace	1.688	0.078					
Hampshire	1.610						

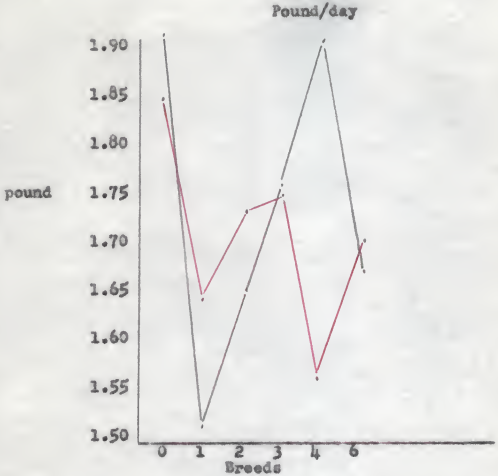

Figure 2. Seasonal effect on daily gain of barrows.

Number	Breed	Number of hogs Fall	Spring	Total
0	Duroc	6	24	30
1	Hampshire	7	26	33
2	Yorkshire	8	20	28
3	Poland China	6	6	12
4	Landrace	3	5	8
5	Berkshire	-	-	-
6	Spotted Poland China	3	6	9
	TOTAL	33	87	120

Red line: Spring pigs
Black line: Fall pigs

Table 5. Season and breed effects on age of boars at 200 pounds body weight.

Source of variation	Analysis of Variance d f	Sum of square	Sum of mean sq.	F
Total	295	43,090		
Years	2	783	291.50	1.9548
Seasons within years	3	2,060	686.66	3.4386 *
Breeds within seasons	33	8.803	266.75	1.3319
Individuals within breeds	157	31.443	200.27	

* Significant at 0.05 level

Table 6. Average age of boars at 200 pounds body weight.

Breeds	No. of boars	Average age at 200 pounds (day)
Duroc	64	149.09
Hampshire	82	152.35
Yorkshire	66	150.10
Poland China	29	156.62
Landrace	23	145.87
Berkshire	13	146.46
Spotted Poland China	19	160.47
Total	296	150.65

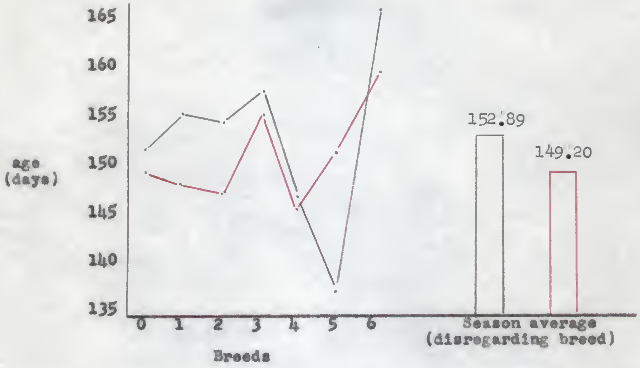

Figure 3. Seasonal effect on the age of boars at 200 pounds body weight.

Number	Breed	Number of hogs Fall	Spring	Total
0	Duroc	23	41	64
1	Hampshire	27	55	82
2	Yorkshire	26	40	66
3	Poland China	17	12	29
4	Landrace	13	10	23
5	Berkshire	4	9	13
6	Spotted Poland China	6	13	19
	TOTAL	116	180	296

Red line: Spring pigs
Black line: Fall pigs

Table 7. Season and breed effects on age of barrows at 200 pounds body weight.

Source of variation	d f	Sum of squares	Sum of mean sq.	F
	Analysis of Variance			
Total	146			
Years	2	2,552	1,276.00	4.820**
Seasons within years	3	1,114	371.30	1.403
Breeds within seasons	32	8,354	261.03	0.403
Individual within breeds	109	28,840	264.58	

** Significant at 0.01 level

Table 8. Average age of barrows, at 200 pounds body weight.

Breeds	Number of barrows	Average age at 200 pounds (day)
Duroc	34	156.12
Hampshire	39	161.72
Yorkshire	32	162.47
Poland China	15	163.00
Landrace	12	155.25
Berkshire	6	157.16
Spotted Poland China	9	163.11
Total Average	147	160.08

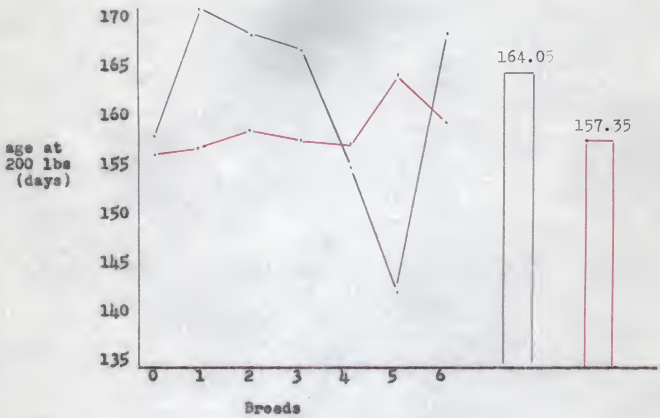

Figure 4. Seasonal effect on the age of barrows at 200 pounds body weight.

Number	Breed	Number of hogs: Fall	Spring	Total
0	Duroc	12	22	34
1	Hampshire	15	24	39
2	Yorkshire	12	20	32
3	Poland China	9	6	15
4	Landrace	7	5	12
5	Berkshire	2	4	6
6	Spotted Poland China	3	6	9
	TOTAL	60	87	147

Red line: Spring pig
Black line: Fall pig

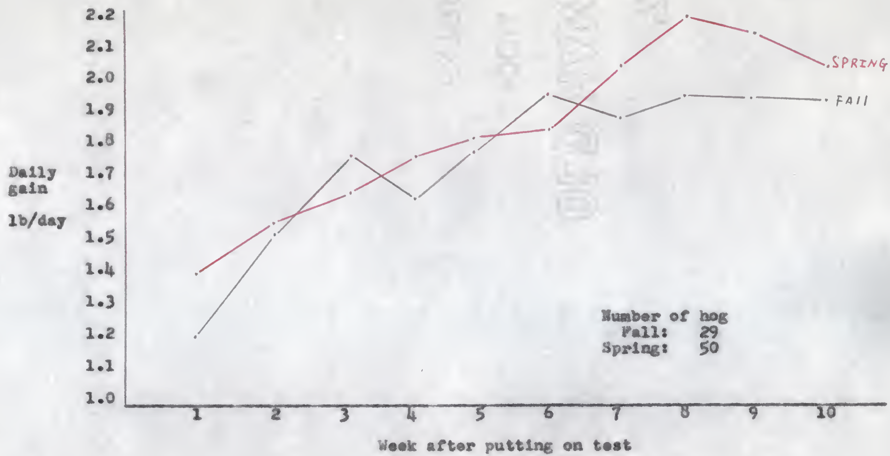

Figure 5. Average daily gain of spring pigs and fall pigs.

Table 9. Weight on the 14th, 35th and 56th day after Duroc, Hampshire and Yorkshire boars started on test.

Breed	Duroc	Hampshire	Yorkshire
No. of boars	56	68	57
Av. initial body wt.	59.75	59.86	61.00
14 days after on test	80.17	80.11	82.68
35 days after on test	120.11	114.44	118.45
56 days after on test	162.46	154.51	158.70

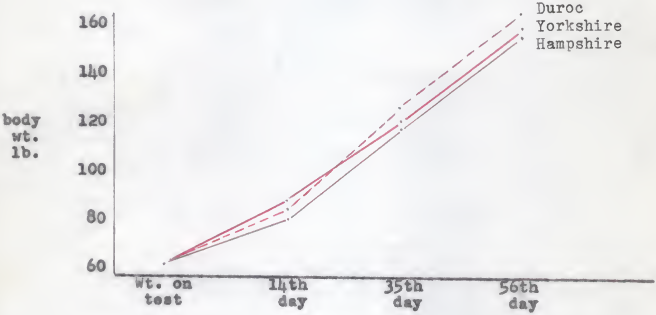

Figure 6. Comparison of body weights at 14th, 35th, 56th day after start of test (boar).

Table 10. Average daily gain of Duroc, Hampshire and Yorkshire in fall and in spring.

Breed	Season	No. of boars	Age on test	Wt. on test	Week									
					1	2	3	4	5	6	7	8	9	10
Duroc	fall	9	73.77	58.66	1.063	1.550	1.760	1.840	1.873	1.968	1.877	2.122	2.444	1.893
	spring	19	76.89	59.26	1.428	1.483	1.769	1.817	1.944	1.897	2.294	2.349	2.270	1.866
	Average	28	75.89	59.07	1.279	1.512	1.767	1.825	1.920	1.920	2.177	2.285	2.328	1.875
Hampshire	fall	8	72.50	57.25	1.357	1.428	1.714	1.482	1.839	1.892	1.946	1.946	1.714	2.142
	spring	25	64.88	61.07	1.365	1.555	1.482	1.785	1.738	1.833	1.940	2.071	2.065	2.011
	Average	33	66.72	60.15	1.362	1.516	1.540	1.709	1.763	1.484	1.941	2.200	1.977	2.044
Yorkshire	fall	12	72.41	59.00	1.131	1.547	1.762	1.512	1.607	1.964	1.809	1.773	1.643	1.738
	spring	16	71.50	61.00	1.336	1.561	1.704	1.683	1.744	1.744	2.020	2.122	2.061	2.183
	Average	28	71.89	60.14	1.241	1.554	1.730	1.604	1.681	1.846	1.923	1.961	1.868	1.978

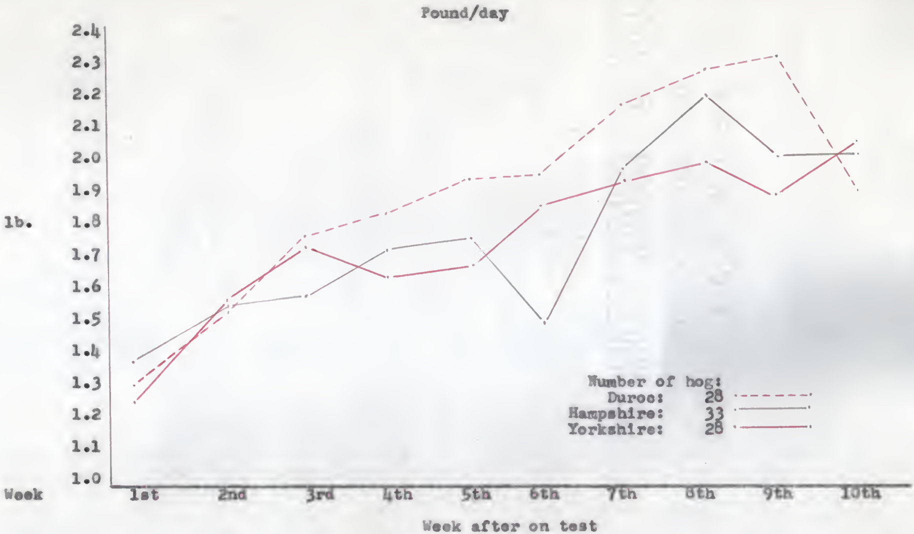

Figure 7. Average daily gain of Duroc, Hampshire and Yorkshire boars.

Table 11. Seasonal effects and breed difference in feed efficiency of boars.

Source of variation	Analysis of Variance d f	Sum of squares	Sum of mean sq.	F
Total	134	28,798		
Years	2	9,428	4,714.00	2.6828
Seasons within years	2	48,357	24,178.50	13.7606**
Breeds within seasons	28	45,791	1,635.39	0.9307
Pens within #2 breeds	102	179,222	1,757.07	

** Significant at 0.01 level
#2 Two littermate boars penned together

Table 12. Average feed efficiency of each breed.

	No. of pens	Average initial weight	Average feed efficiency (feed intake / 200 pounds gain)
Duroc	30	59.75	545.13
Hampshire	37	59.86	563.45
Yorkshire	30	61.00	548.70
Poland China	12	60.13	575.50
Landrace	10	61.86	576.10
Berkshire	6	62.81	572.33
Spotted Poland China	16	59.05	576.60
Total	135	60.31	559.48

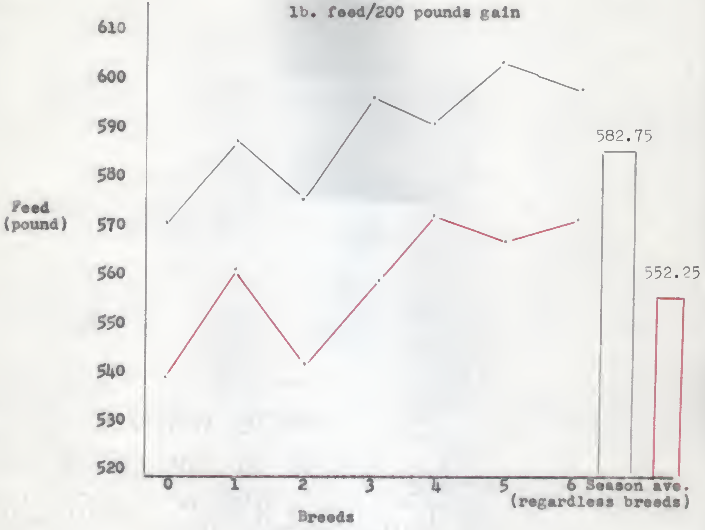

Figure 8. Seasonal effect on feed efficiency of boars.

Number	Breed	Number of pens* Fall	Spring	Total
0	Duroc	6	24	30
1	Hampshire	5	32	37
2	Yorkshire	8	22	12
3	Poland China	6	6	12
4	Landrace	3	7	10
5	Berkshire	1	5	6
6	Spotted Poland China	3	7	10
	Total	32	103	135

Red line: Spring pig
Black line: Fall pig

* Two boars each pen

Table 13. Effect of breed and season on the live hog backfat thickness of boars.

Source of variation	Analysis of Variance: d f	Sum of squares	Sum of mean sq.	F
Total	315	10.2755		
Years	2	0.0641	0.03205	1.1603
Seasons within years	3	0.1030	0.03433	1.2429
Breed within seasons	34	2.4848	0.07308	2.6459**
Individuals within breeds	276	7.6236	0.02762	

** Significant at 0.01 level

Table 14. (a) Comparison of breeds on the basis of backfat thickness of boars.

	No. of boars	Average backfat thickness
Duroc	72	1.188
Hampshire	91	1.075
Yorkshire	67	1.070
Poland China	29	1.107
Landrace	23	1.099
Berkshire	13	1.051
Spotted Poland China	21	1.032
Total	316	1.101

(b) Turkey's L.S.D. comparison

Breeds	Average backfat thickness	Duroc	Poland China	Landrace	Hamp-shire	York-shire	Berk-shire
		1.188	1.107	1.099	1.075	1.070	1.051
Spotted Poland China	1.032	0.156*	0.075	0.067	0.043	0.038	0.019
Berkshire	1.051	0.137*	0.056	0.048	0.024	0.019	
Yorkshire	1.070	0.118*	0.037	0.029	0.005		
Hampshire	1.075	0.113*	0.032	0.024			
Landrace	1.099	0.089*	0.008				
Poland China	1.107	0.081*					

* Significant at 0.05 level.

Table 15. Seasonal effect and breed difference on the live hog backfat thickness of barrows.

Source of variation	Analysis of Variance d f	Sum of squares	Sum of mean sq.	F
Total	155	6.3913		
Years	2	0.0092	0.00460	0.1331
Seasons within years	3	0.3643	0.12140	3.5127*
Breeds within seasons	33	1.9986	0.06056	1.7523*
Individuals within breeds	117	4.0436	0.03456	

* Significant at 0.05 level.

Table 16. (a) Comparison of breeds on the basis of backfat thickness of barrows.

Breeds	No. of barrows	Av. backfat thickness
Duroc	37	1.499
Hampshire	45	1.366
Yorkshire	33	1.463
Poland China	15	1.451
Landrace	11	1.291
Berkshire	5	1.394
Spotted Poland China	10	1.365
Total average	156	1.421

(b) Turkey's L.S.D. comparison

Breed		Duroc	York-shire	Poland China	Berk-shire	Hamp-shire	Spotted P. China
	Average backfat thickness	1.499	1.463	1.451	1.394	1.366	1.365
Landrace	1.291	0.208*	0.172*	0.160*	0.103	0.075	0.074
Spotted Poland China	1.365	0.134*	0.098	0.086	0.029	0.001	
Hampshire	1.366	0.133*	0.097*	0.085	0.028		
Berkshire	1.394	0.105	0.069	0.057			
Poland China	1.451	0.048	0.012				
Yorkshire	1.463	0.036					

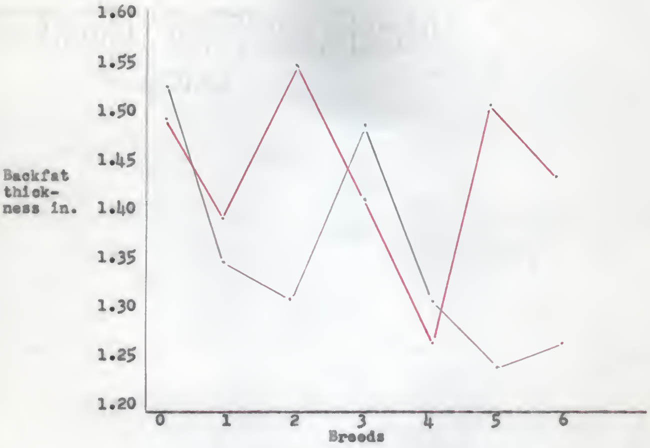

Figure 9. Seasonal effect on the live hog backfat thickness of barrows.

Number	Breed	Number of hogs Fall	Spring	Total
0	Duroc	13	24	37
1	Hampshire	19	26	45
2	Yorkshire	12	21	33
3	Poland China	9	6	15
4	Landrace	7	4	11
5	Berkshire	2	3	5
6	Spotted Poland China	4	6	10
	Total	66	90	156

Red line: Spring pigs
Black line: Fall pigs

Table 17. Seasonal effects and breed differences in the carcass length of barrows.

Source of variation	Analysis of Variance d f	Sum of squares	Sum of mean sq.	F
Total	149	141.79		
Years	2	1.14	0.5700	1.335
Seasons within years	3	6.51	2.1700	5.085**
Breed within seasons	32	86.34	2.6981	6.323**
Individuals within breeds	112	47.80	0.4267	

** Significant at 0.01 level.

Table 18. (a) Comparison of breed, differences in the carcass length of barrows.

Breeds	No. of barrows	Average carcass length (inch)
Duroc	36	28.833
Hampshire	42	29.069
Yorkshire	32	29.840
Poland China	15	28.080
Landrace	10	30.920
Berkshire	5	29.200
Spotted Poland China	10	28.590
Total Average	150	29.174

(b) Turkey's L.S.D. comparison

Breeds	Average carcass length (inch)	Poland China	Spotted Poland China	Duroc	Hamp-shire	Berk-shire	York-shire
		28.080	28.590	28.833	29.069	29.200	29.840
Landrace	30.920	2.840*	2.330*	2.087*	1.851*	1.720*	1.080*
Yorkshire	29.840	1.760*	1.250*	1.007*	0.771*	0.640*	
Berkshire	29.200	1.120*	0.610	0.367	0.131		
Hampshire	29.069	0.989*	0.479*	0.236			
Duroc	28.833	0.753*	0.243				
Spotted Poland China	28.590	0.510					

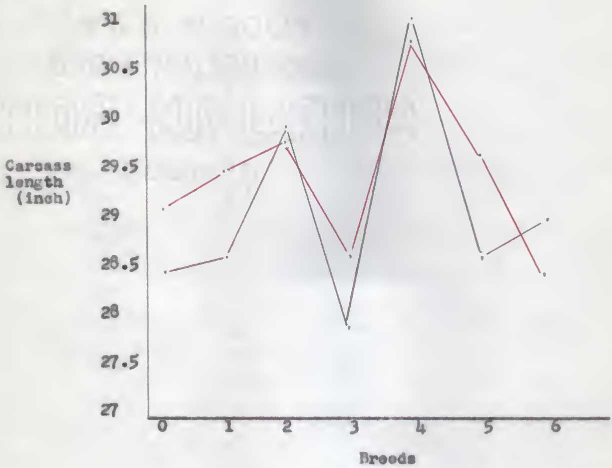

Figure 10. Seasonal effect on the carcass length of barrows.

Number	Breed	Number of hogs Fall	Spring	Total
0	Duroc	13	23	36
1	Hampshire	18	24	42
2	Yorkshire	12	20	32
3	Poland China	9	6	15
4	Landrace	6	4	10
5	Berkshire	2	3	5
6	Spotted Poland China	4	6	10
	Total	64	86	150

Red line: Spring pig
Black line: Fall pig

Table 19. Seasonal effect and breed difference on the percent of lean cuts of barrows.

Source of variation	d f	Sum of squares	Sum of mean sq	F
	Analysis of Variance			
Total	151	1369.48		
Years	2	70.45	35.220	4.054*
Seasons within years	3	52.41	17.470	2.011
Breeds within season	33	264.99	8.030	0.924
Individual within breeds	113	981.63	8.686	

* Significant at 0.05 level

Table 20. Average percentage of lean cuts for each breed.

Breeds	No. of barrows	Av. percent of lean cuts
Duroc	37	47.421
Hampshire	42	49.319
Yorkshire	32	48.012
Poland China	15	48.193
Landrace	10	49.560
Berkshire	6	46.633
Spotted Poland China	10	48.550
Total Average	152	48.330

Table 21. Seasonal effects and breed differences in the loin eye area of barrows.

Source of variation	d f	Analysis of Variance: Sum of squares	Sum of mean sq.	F
Total	145	40.2527		
Years	2	1.8376	0.918	4.08 *
Seasons within years	3	3.6355	1.211	5.38 **
Breeds within seasons	32	10.4703	0.327	1.45
Individual within breeds	108	24.3093	0.225	

Table 22. Average loin eye area of each breed.

Breeds	No. of barrows	Average loin eye area (sq. in)
Duroc	36	3.377
Hampshire	42	3.769
Yorkshire	32	3.623
Poland China	14	3.946
Landrace	8	3.817
Berkshire	5	3.846
Spotted Poland China	9	4.153
Total Average	146	3.686

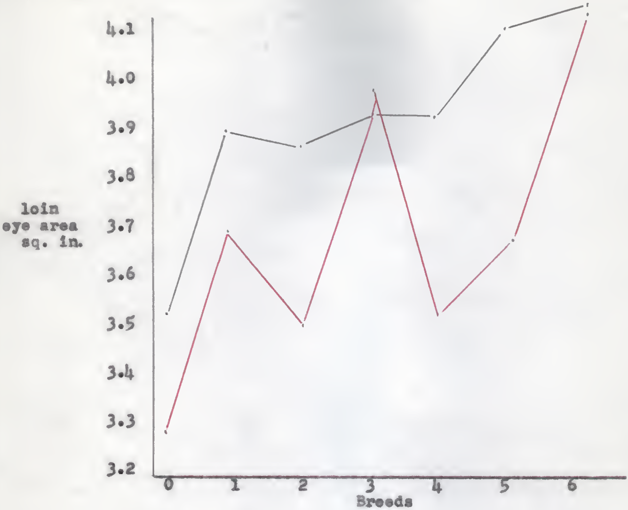

Figure 11. Seasonal effect on the loin eye area of barrows.

Number	Breed	Number of hogs Fall	Spring	Total
0	Duroc	13	23	36
1	Hampshire	18	24	42
2	Yorkshire	12	20	32
3	Poland China	9	5	14
4	Landrace	6	2	8
5	Berkshire	2	3	5
6	Spotted Poland China	4	5	9
	Total	64	82	146

Red line: Spring pigs
Black line: Fall pigs

Table 23. Correlation between sale price, index, feed efficiency, daily gain, age to 200 pounds, backfat thickness.
(a) over all breeds (boars)

	Sale price	Index	Feed efficiency	Daily gain	Age to 200 lbs.
Sale price					
Index	.472**				
Feed efficiency	-.086	-.663**			
Daily gain	.317**	.335**	-.131		
Age to 200 lbs.	-.197**	-.370**	.210**	-.540**	
Backfat thickness	-.166*	-.321**	-.176*	.465**	-.208**

Computed from 214 boars

* Significant at 0.05 level
** Significant at 0.01 level

(b) Duroc breed		1 Sale price	2 Index	3 Feed efficiency	4 Daily gain	5 Age to 200 lbs
Duroc number 55	1. Sale price					
	2. Index	.509**				
	3. Feed efficiency	-.395**	-.758**			
	4. Daily gain	.283*	.309*	-.152		
	5. Age to 200 lbs.	.083	-.259	.237	-.524**	
	6. Backfat thickness	-.150	-.472**	0.138	.454**	-.372**

(c) Hampshire breed

	1. Sale price					
Hampshire number 59	2. Index	.449**				
	3. Feed efficiency	-.041	-.621**			
	4. Daily gain	.417**	.177	-0.053		
	5. Age to 200 lbs.	-.321**	-.279*	- .037	-.576**	
	6. Backfat thickness	-.146	-.479**	- .071	.508**	-.087

(d) Poland China breed		1 Sale price	2 Index	3 Feed efficiency	4 Daily gain	5 Age to 200 lbs.
Poland China number 19	1. Sale price					
	2. Index	.396				
	3. Feed efficiency	-.145	-.531*			
	4. Daily gain	.206	-.113	.359		
	5. Age to 200 lbs.	-.160	.109	-.202	-.420	
	6. Backfat thickness	-.099	-.597**	-.106	.363	-.221

(e) Landrace breed

		1 Sale price	2 Index	3 Feed efficiency	4 Daily gain	5 Age to 200 lbs.
	1. Sale price					
	2. Index	.132				
	3. Feed efficiency	-.349	-.379			
Landrace number 8	4. Daily gain	.320	.840**	-.378		
	5. Age to 200 lbs.	-.159	-.806**	.729**	-.865**	
	6. Backfat thickness	.504	.277	-.954**	.424	-.697*

(f) Yorkshire breed

		1 Sale price	2 Index	3 Feed efficiency	4 Daily gain	5 Age to 200 lbs.
Yorkshire number 54	1. Sale price					
	2. Index	.446**				
	3. Feed efficiency	.057	-.598**			
	4. Daily gain	.327*	.363**	.054		
	5. Age to 200 lbs.	-.214	-.759**	.555**	-.479**	
	6. Backfat thickness	-.294*	-.190	-.318*	.379**	-.200

(g) Berkshire breed

		1 Sale price	2 Index	3 Feed efficiency	4 Daily gain	5 Age to 200 lbs.
Berkshire number 8	1. Sale price					
	2. Index	.503				
	3. Feed efficiency	-.175	-.881**			
	4. Daily gain	.845**	.735*	-.346		
	5. Age to 200 lbs.	-.933**	-.520	.213	-.787**	
	6. Backfat thickness	-.201	-.689*	.689*	-.292	.394

(h) Spotted Poland China breed

		1 Sale price	2 Index	3 Feed efficiency	4 Daily gain	5 Age to 200 lbs.
Spotted Poland China number 11	1. Sale price					
	2. Index	.545				
	3. Feed efficiency	-.200	-.832**			
	4. Daily gain	-.088	.304	-.471		
	5. Age to 200 lbs.	-.078	-.196	.231	-.466	
	6. Backfat thickness	-.530	-.267	-.189	.739**	-.315

Table 24. Seasonal and breed differences in the sale price of boars.

Source of variation	Analysis of Variance d f	Sum of squares	Sum of mean sq.	F
Total	288	1,635,236		
Years	2	124,144	62,072.00	12.994**
Seasons within years	3	49,731	16,577.00	3.470*
Breeds within seasons	33	267,121	8,094.57	1.694*
Individuals within breeds	250	1,194,240	4,776.96	

* Significant at 0.05 level
** Significant at 0.01 level

Table 25. Number of boars sold and average sale price.

Breeds	No. of boars sold	Average price (dollars)
Duroc	68	173.55
Hampshire	83	171.15
Yorkshire	63	193.66
Poland China	26	158.46
Landrace	19	105.00
Berkshire	13	127.30
Spotted Poland China	17	137.35
Total Average	289	167.18

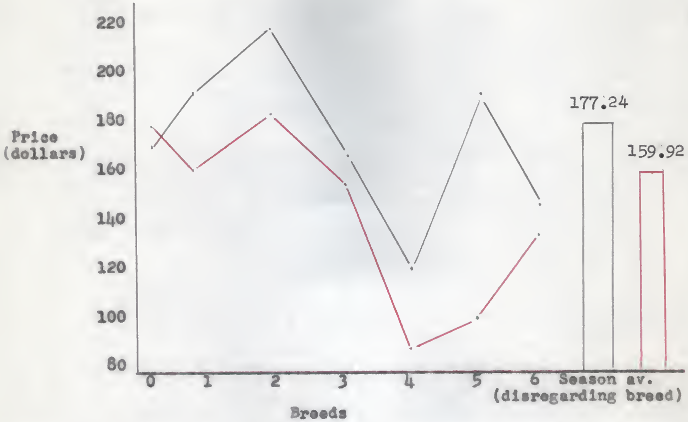

Figure 12. Seasonal difference in the sale price of boars.

Number	Breed	Number of hogs Fall	Spring	Total
0	Duroc	26	42	68
1	Hampshire	33	50	83
2	Yorkshire	24	39	63
3	Poland China	16	10	26
4	Landrace	11	8	19
5	Berkshire	4	9	13
6	Spotted Poland China	7	10	17
	Total	121	168	289

Red line: Spring pig
Black line: Fall pig

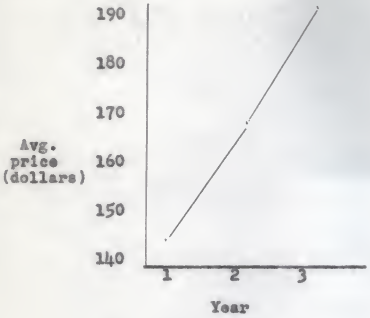

Figure 13. Yearly difference in sale price of boars.

PERFORMANCE OF VARIOUS BREEDS OF SWINE
UNDER CENTRAL TESTING STATION CONDITIONS IN
WINTER AND SUMMER

by

JU TUNG YU

B. S., National Taiwan University, 1952

AN ABSTRACT OF A THESIS

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requirements for the degree

MASTER OF SCIENCE

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Data concerning feed efficiency, backfat thickness, daily gain and carcass quality from 316 boars and 157 barrows was studied to determine seasonal effects and breed differences in pig performance under central testing station conditions. In addition to this, the correlations between live hog backfat thickness, feed efficiency, daily gain and age to 200 pounds were also studied.

The analysis of variance indicated significant seasonal effects on feed efficiency, daily gain, backfat thickness (barrows only), age to 200 pounds (boars only), carcass length, and loin eye area. Spring fed pigs had significantly better ($P < .01$) feed efficiency than fall fed pigs. The difference averaged 30.5s pound per 200 pounds of gain. Daily gain was found to be significantly ($P < .05$) higher in spring. Ambiant temperature below 32°F apparently affected the daily gain of the fall fed pigs. Spring boars were found to reach 200 pounds body weight at a significantly ($P < .05$) earlier age than fall boars. Spring pigs had longer carcass length in the case of the Hampshire breed ($P < .01$), the Duroc breed ($P < .05$) and the Poland China breed ($P < .05$) but not in the Yorkshire and other breeds. Loin eye area was found to be larger in carcasses from fall-fed barrows. However, this was significant ($P < .05$) in the Yorkshire breed only. No significant seasonal effect was found on the percent of lean cuts. In summary under the central testing station conditions, the spring pigs had better feed efficiency, higher daily gain and greater carcass length but were higher in backfat thickness and smaller in loin eye area. However, this was not

true for all breeds.

Significant differences in performance between breeds were found for daily gain, backfat thickness and carcass length. Durocs had significantly faster gains (boar $P < .10$, barrow $P < .05$) than any other breeds studied (Hampshire, Landrace, Spotted Poland China, Yorkshire and Poland China) except Berkshires. However, no significant difference between breeds in age at 200 pounds body weight was found. This was possibly due to the fact that Durocs were older when they went on test at 60 pounds body weight. Highly significant differences in live hog backfat thickness were found between breeds in boars and significant differences were found between breeds in barrows. Duroc boars had significantly higher backfat thickness than any breed studied. In barrows, the Duroc breed had significantly higher backfat thickness than Spotted Poland China and Hampshire, Landrace barrows had significantly less backfat thickness than Yorkshires and Poland Chinas.

No significant differences in loin eye area or percent of lean cuts was found between breeds. However, highly significant differences in carcass length were found between breeds. The Yorkshire breed ranked second longest in carcass length to the Landrace breed, and both were significantly longer than any other breed studied. Poland Chinas and Spotted Poland Chinas were shortest among the breeds studied.

Correlations between backfat thickness, feed efficiency, daily gain and age to 200 pounds indicated that the correlation

between these traits varied from breed to breed. Both Landrace and Yorkshires showed a significant negative correlation (Landrace $r = -.954$, $P < .01$, Yorkshire $r = -.318$, $P < .05$) between the feed efficiency and backfat thickness. Berkshires showed a significant positive correlation ($r = .689$, $P < .05$) between these two traits.

Significant positive correlations between backfat thickness and d aily gain were found for Durocs ($r = .454$, $P \ .01$), Hampshires ($r = .508$, $P < .01$) Yorkshires $r = .378$, $P < .01$) and Spotted Poland Chinas ($r = .739$, $P < .01$). The correlation between age at 200 pounds and backfat thickness was found to be significant in Durocs ($r = -.372$, $P < .01$) and Landrace ($r = .696$, $P < .05$). If breed was disregarded the correlations between the backfat thickness and feed efficiency, daily gain, age to two pounds were $-.175$ ($P < 0.05$), $.465$, ($P < 0.01$) and 2.08 ($P < 0.01$) respectively. It was concluded those higher in backfat thickness had better feed efficiency in the Landrace and Yorkshire breed, faster daily gain in the Duroc, Hampshire, Yorkshire and Spotted Poland China breeds earlier age to reach 200 pounds of body weight in Duroc and Landrace. In the Berkshire breed, those higher in backfat thickness had poorer feed efficiency were slower in daily gain and took longer to reach 200 pounds body weight. The correlations between the backfat thickness and the latter two traits were not significant.

The correlation coefficient between the average of three measurements (behind shoulder, last rib and middle loin) and the

third measurement (middle loin) was highly significant ($r = .93$, $P < .01$). This indicated that the single measurement at the middle loin was approximate as accurate as the average for the three measurements.